CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONN.

BULLETIN 195, JULY, 1917

ENTOMOLOGICAL SERIES, No. 24.

INSECTS INJURING STORED FOOD PRODUCTS IN CONNECTICUT

By W. E. BRITTON, *State Entomologist.*

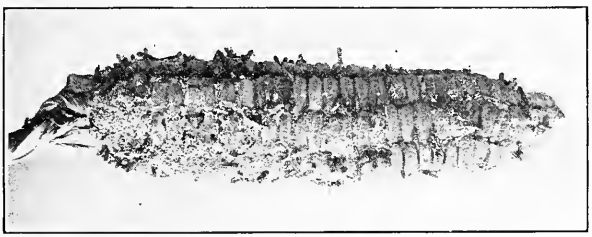

FIGURE 1. Ear of corn injured by the European grain moth, half natural size.

CONTENTS.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

OFFICERS AND STAFF.

BOARD OF CONTROL.

His Excellency, Marcus H. Holcomb, *ex-officio, President.*

James H. Webb, *Vice President*.....Hamden
George A. Hopson, *Secretary*.....Wallingford
E. H. Jenkins, *Director and Treasurer*.....New Haven
Joseph W. Alsop.....Avon
Wilson H. Lee.....Orange
Frank H. Stadtmueller.....Elmwood

Administration.
E. H. Jenkins, Ph.D., *Director and Treasurer.*
Miss V. E. Cole, *Librarian and Stenographer.*
Miss L. M. Brautlecht, *Bookkeeper and Stenographer.*
William Veitch, *In charge of Buildings and Grounds.*

Chemistry.

Analytical Laboratory.
John Phillips Street, M.S., *Chemist in Charge.*
E. Monroe Bailey, Ph.D.,
C. B. Morison, B.S., C. E. Shepherd, } *Assistants.*
W. L. Adams, B.S.
Hugo Lange, *Laboratory Helper.*
V. L. Churchill, *Sampling Agent.*

Proteid Research.
T. B. Osborne, Ph.D., D.Sc., *Chemist in Charge.*
Miss E. L. Ferry, M.S., *Assistant.*

Botany.
G. P. Clinton, Sc.D., *Botanist.*
E. M. Stoddard, B.S., *Assistant Botanist.*
Florence A. McCormick, Ph.D., *Scientific Assistant*
G. E. Graham, *General Assistant.*

Entomology.
W. E. Britton, Ph.D., *Entomologist; State Entomologist.*
B. H. Walden, B.Agr., *First Assistant.*
Q. S. Lowry, B.Sc., I. W. Davis, B.Sc., } *Assistants.*
M. P. Zappe, B.S.,
Miss G. A. Foote, B.A., *Stenographer.*

Forestry.
Walter O. Filley, *Forester; also State Forester and State Forest Fire Warden.*
A. E. Moss, M.F., *Assistant State and Station Forester.*
Miss E. L. Avery, *Stenographer.*

Plant Breeding.
Donald F. Jones, M.S., *Plant Breeder.*
C. D. Hubbell, *Assistant.*

Vegetable Growing. ——.

Insects Injuring Stored Food Products in Connecticut.

By W. E. Britton, State Entomologist.

The importance of growing more food for the people of this country cannot be over-emphasized, and the various efforts along this line and the publications giving information regarding methods are all praiseworthy. Nevertheless, it is perhaps equally important to conserve the food supplies already grown and stored. It has been estimated that insects take an annual toll of about five per cent of the value of the stored food products, amounting to $200,000,000.00 each year, in the United States. Most of this loss is wholly preventable if attention is given the matter at the right time, and there is no time when control methods can be enforced with greater profit to the owner, or with greater benefit to our country and to mankind than the present.

The object of this bulletin is to place before the people of Connecticut a brief account of the principal insects attacking and injuring stored grains and food products in the state, and to suggest methods of controlling them. The figures are included for the purpose of illustrating the text and of giving an idea of the general appearance of the insects.

These insects belong in two large natural groups: the Beetles (Coleoptera) and the Moths (Lepidoptera). The principal features of each are given to enable the reader to identify the species, but as control measures are similar for all, information on this point is given in a separate chapter on page 16 of this bulletin.

THE GRAIN BEETLES.

The Common Meal Worm, *Tenebrio molitor* Linn.

In and around the bottoms of bins and barrels where corn meal, flour, or other cereals are stored, one often finds yellow larvae about an inch in length and resembling wire worms. These feed upon the meal and are called meal worms.

The adult is a shining, black or dark brown, beetle, somewhat more than half an inch in length, with thorax rather finely punctured and wing-covers longitudinally striated or grooved. The

beetle lays its white eggs in the meal, usually in masses, with a juice or sticky material which causes the meal to adhere to the eggs. The eggs hatch in about two weeks and the larvae feed upon the meal for three months or longer before pupating. The pupal stage requires about two weeks, and normally there seems

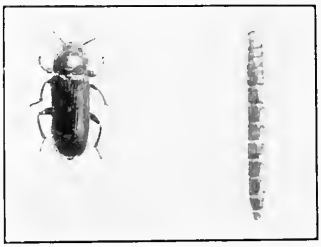

FIGURE 2. Common meal worm, adult and larva, natural size.

to be but one generation each year. The adults mostly emerge in the spring, but where the meal is stored in the house, or in a heated building, they may appear at any time of the year. This insect is shown in figure 2.

THE DARKER MEAL WORM, *Tenebrio obscurus* Fabr.

This insect is much like the preceding except that the larvae are darker in color and the adult beetles are dull instead of shiny. The life history and injuries are similar and both often occur in the same place.

The treatment is also the same for both species, viz.: fumigating with carbon disulphide or heating the meal in an oven for a short time.

THE CADELLE, *Tenebrioides mauritanicus* Linn.

The larva of this beetle is dirty-white, with head, prothorax and tip of abdomen dark brown, and when fully grown it measures about three-fourths of an inch in length. It has the habit of tunneling into wood to make its cocoon, at least when soft pine is available. The pupa stage evidently lasts three or four weeks.

The adult beetle is brown and shiny, and about three-eighths of an inch long. It lays white eggs which are a trifle over a millimeter long and one-fourth as thick.

There is a single generation annually, and the cadelle feeds on various kinds of stored foods and plant products and is also partially predaceous, as Chittenden* states that both larvae and adults attack and destroy other grain insects which they encounter. Nevertheless, the cadelle is capable of causing con-

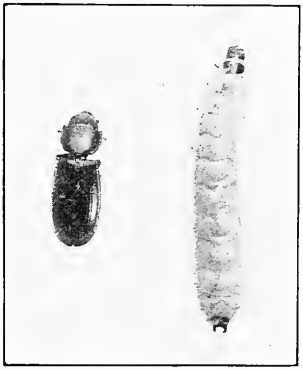

FIGURE 3. Cadelle, adult and larva, twice natural size.

siderable injury and the treatment is the same as for the other meal worms. The larvae of the cadelle have been reported from many unexpected places, such as in sugar, in bottles of milk, in powdered hellebore, and boring through the parchment paper of jars of jams and jellies. In some of these places they probably occurred accidentally. Larva and adult are shown in figure 3.

THE PEA WEEVIL, *Bruchus pisorum* Linn.

The adult beetle is about one-fifth of an inch long, and the wing covers are marked with small black and white spots. It lays eggs singly on the outside of the green pods in the field, and the larva tunnels through the pods and into one of the green peas. The insect does not mature until the peas have ripened and have been harvested and placed in storage. Then it is common to find a single round hole in a pea where the adult has emerged. Sometimes nearly every pea has a hole in it, and many larvae are unquestionably cooked and eaten in green peas;

* F. H. Chittenden, Farmer's Bulletin No. 45, U. S. Department of Agriculture, page 19, 1896.

but the insect does not go on breeding in dry stored peas, there being only one brood each year.

The pea weevil is more serious in the Middle Atlantic than in the Northern States, but it is present in Connecticut. In the Southern States it is claimed that late planting brings compara-

FIGURE 4. Pea weevil, adult beetle, four times enlarged.

tive immunity from attack but in the writer's experience late planted peas seldom produce a satisfactory crop here. Hence it is better to treat the seed soon after harvesting, and to make allowance in planting for a certain percentage of injured seed. This insect is shown in figure 4.

THE COMMON BEAN WEEVIL, *Bruchus obtectus* Say.

This is probably the greatest enemy of beans in Connecticut, and though in size somewhat smaller than the pea weevil and

FIGURE 5. Common bean weevil. Adult beetles, four times enlarged.

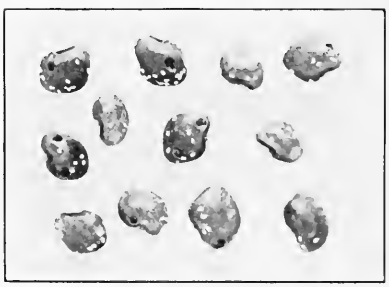

FIGURE 6. Infested cow peas, showing eggs and exit holes of bean weevil, natural size.

resembling it in color and markings, it differs from it by continuing to breed in the dry, stored seed. There are six generations annually in the District of Columbia, and a smaller number in the northern states. Stored beans are often entirely destroyed, or at least rendered unfit for planting, or as food for man or beast. The beans often have several holes in each where the adults have emerged, and as many as 28 have been found in a single seed. Severely weeviled beans are almost useless for planting, but the good seed may be separated from the infested seed by throwing into water. The injured seed will float and may be discarded. This beetle and its work are shown in figures 5 and 6.

The Four-Spotted Bean Weevil, *Bruchus quadrimaculatus* Fabr.

This species is somewhat more slender than the preceding and has different markings. Its habits and life history are similar and the same control methods may be practiced.

The Drug Store Beetle, *Sitodrepa panicea* Linn.

Of all the insects attacking stored food products, perhaps none is more cosmopolitan or feeds upon a greater number of different kinds than the drug store beetle. It is a common pest of all kinds of stored vegetable foods and may be found in breakfast

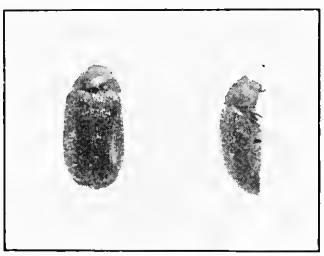

Figure 7. Drug store beetle. Adults, four times enlarged.

foods, or the dried roots, stems, bark, and seed capsules commonly called spices. It feeds also on the parts of plants used as drugs, often eating those which are bitter and poisonous to man. It has been recorded as attacking forty-five different drugs. It is now distributed throughout the civilized world, and four or

five generations may occur in a year, especially in a heated building.

The beetle is about one-tenth of an inch in length, covered with a silky pubescence, and reddish-brown in color. The wing-covers are longitudinally striated and the antennae terminate in three long segments forming the so-called "club." The larvae are white, with dark mouth parts, and assume a curved attitude when at work in their burrows. The adult is shown in figure 7.

The Confused Flour Beetle, *Tribolium confusum* Duv. and The Rust-red Flour Beetle, *Tribolium ferrugineum* Fabr.

The confused flour beetle has been known to occur in this country for nearly twenty-five years and has caused injury throughout the land. It attacks seeds, stored cereals and other starchy foods and drugs, and is a pest in flour and grain mills.

The adult is a flattened brown beetle, less than a sixth of an inch in length. There may be as many as four generations annually in a heated storehouse.

The rust red flour beetle closely resembles the preceding, but is not nearly as common in Connecticut. It is a pest in the Southern States and is often shipped north in rice or other starchy food products.

The Saw-toothed Grain Beetle, *Silvanus surinamensis* Linn.

One of the most common beetles in grain and stored food products is the saw-toothed grain beetle. It is less than an eighth of an inch long, flattened, grooved longitudinally, with teeth-

Figure 8. Saw-toothed grain beetle, four times enlarged.

like projections on the sides of the thorax, and brown in color. The larva is white, extremely active, and makes its pupa case on some convenient surface by joining together particles of the infested material with some adhesive substance which it secretes.

There are probably four or five generations each year, and the beetles eat through paper bags and pasteboard boxes to reach foodstuffs inside. Though perhaps preferring farinaceous foods, this beetle often infests fruits and almost all kinds of stored food products. This beetle and its injury to corn are shown in figures 8 and 9.

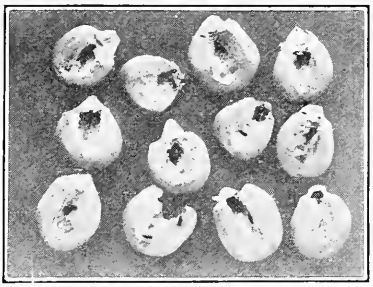

FIGURE 9. Peruvian seed corn injured by saw-toothed grain beetle, reduced one-half.

A flat, smooth, reddish-brown beetle, still smaller than the preceding, is occasionally found infesting wheat bran or other cereals. This is *Læmophlœus pusillus* Schr., one of the minor pests but nevertheless capable of causing much injury.

THE GRANARY WEEVIL, *Calandra granaria* Linn.

Both this weevil and the following belong to the family Calandridae or snout beetles. The adult is a shiny reddish-brown snout beetle nearly an eighth of an inch in length, with a long proboscis. The larva is a legless grub. Both adult and larva feed upon the kernels of the grain. There are four or five generations each year in the vicinity of Washington, D. C., and more farther south. It attacks and injures maize and all of the small grains.

THE RICE WEEVIL, *Calandra oryzae* Linn.

This species resembles the preceding except that it is dull brown instead of shining, and the thorax is more densely pitted. There are four more or less distinct red spots on the wing-covers. This insect is often found in the field and takes its name from

the rice which it infests. Its habits and life history are otherwise similar to the preceding. It is shown in figure 10.

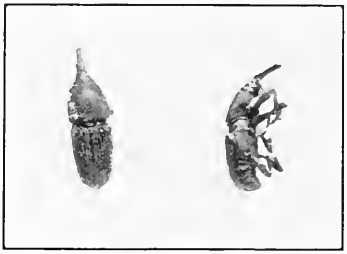

FIGURE 10. Rice weevil. Adults four times enlarged.

THE FLOUR AND MEAL MOTHS.

THE INDIAN MEAL MOTH, *Plodia interpunctella* Hubn.

Considerable damage is done each year in mills, granaries, seed warehouses, etc., by the Indian meal moth, which is also a common pest of the household, as it attacks nearly all kinds of

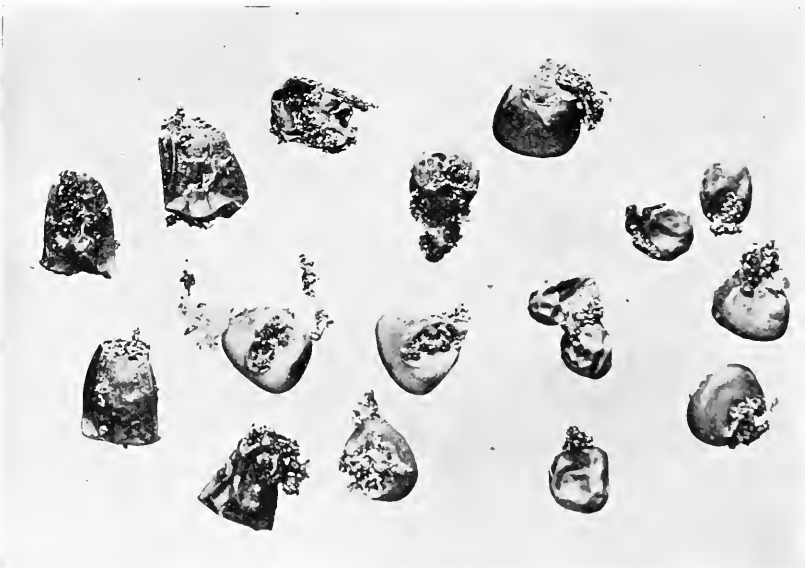

FIGURE 11. Kernels of corn injured by the Indian meal moth. Natural size.

vegetable food products. Each year some food material infested by this insect is brought to the writer's attention. In 1905 some large seed warehouses near New Haven were found infested, and one room was fumigated with hydrocyanic acid gas. This treatment killed the larvae crawling about, and those at work near the outside of the bags, and at first seemed to be effective. Later, however, living larvae appeared from inside, showing that the gas did not penetrate far into the mass of grain.

The larvae web together the grain and flour, especially around the outside. One 100-pound bag of corn was emptied and seven pounds adhered to the bag. The kernels were eaten at the embryo, and are shown in figure 11.

The eggs are small, white, and laid singly or in groups, and each female may lay as many as 350. The larva is whitish, and spins a silk thread wherever it feeds and travels, and the web

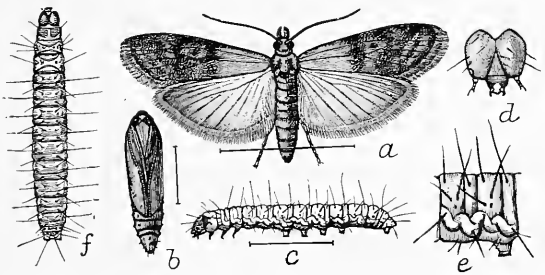

FIGURE 12. Indian meal moth. *a*, adult; *b*, pupa; *c*, larva, side view; *d*, head of larva, front view; *e*, first abdominal segment of larva; *f*, larva, dorsal view—all greatly enlarged. (After Chittenden, Bur. of Ent., U. S. Dept. of Agriculture.)

holds together the particles of food material. Pupation takes place in a silken cocoon-like web from which the moths emerge. From four to five weeks only are required for a generation to develop. In a heated building this insect will breed throughout the year.

The adult is a small moth having a wing-spread of about five-eighths of an inch; forewings whitish at base with distal half reddish-brown, as shown in figure 12.

THE MEDITERRANEAN FLOUR MOTH, *Ephestia kuehniella* Zell.

This insect is regarded by Chittenden as the most important of all the species infesting flour and grain mills. It has been

reared from flour in New Haven and has been taken at Branford. In life history and injury the Mediterranean flour moth resembles the Indian meal moth, and in heated buildings five or six broods may occur each year. The moth is shown in figure 13. It is

FIGURE 13. Mediterranean flour moth and cocoons, slightly enlarged.

larger than the Indian meal moth and has a wing-spread of about an inch. The forewings are dull lead-gray, crossed by zigzag darker lines or bands. Not only does this insect injure flour and grain but also feeds upon almost any kind of stored vegetable food products.

THE MEAL SNOUT MOTH, *Pyralis farinalis* Linn.

This insect infests flour, meal, and other stored food products, though not as serious a pest as the Indian meal moth or the Mediterranean flour moth.

The larvae have the habit of constructing long tubes by binding together with silk small particles of the meal or food material. In these tubes the larvae live and hide until fully grown when

FIGURE 14. Meal snout moth. Natural size.

they leave the tubes and spin their cocoons, usually in or just outside of the infested material. There are probably three or four generations each year, though further studies are needed in this latitude to determine this point.

The adult has a wing-spread of about an inch, is light brown, with thorax, base and apex of fore wings darker brown, and with whitish wavy lines crossing front and rear wings, as shown in figure 14.

THE GRAIN MOTHS.

The Angoumois Grain Moth, *Sitotroga cerealella* Oliv.

This destructive insect was known in France nearly two hundred years ago, and was somehow brought to this country in the early colonial days, and became established in North Carolina and Virginia. Since then it has spread northward to Massachusetts, New York and Michigan and throughout the southern states, where it does much damage. The writer first noticed it in Connecticut nearly twenty years ago, and has run across it a number of times since. It is primarily a pest of stored grains, especially corn on the ear, which if infested soon appears as in

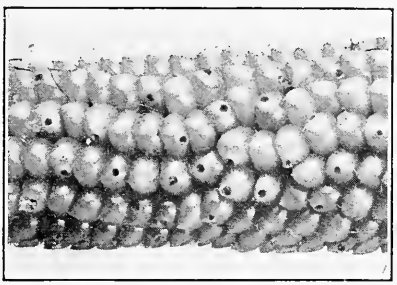

Figure 15. Pop corn showing exit holes of Angoumois grain moth. Natural size.

figure 15. The emerging moths leave small circular holes in the kernels. Infested grain is injured not only for seed, but also for feeding purposes; as it has been estimated that it loses within six months 40 per cent of its weight and 75 per cent of the starchy matter. The moth lays whitish eggs on the kernels of corn, and they soon turn to a pale reddish color and hatch in five or six days. Two or more larvae may occupy a single kernel of maize, though only one occurs in a grain of wheat. The adult is a light, grayish-brown moth, having a wing-expanse of about half an inch, somewhat resembling a clothes moth. Out of doors in the southern states there are at least four broods

annually and the larva passes the winter in kernels of grain. In this climate it breeds only in stored grain, and in heated buildings this goes on continuously, there probably being five or six generations, depending upon the temperature.

The European Grain Moth, *Tinea granella* Linn.

Compared with the Angoumois grain moth this moth is of secondary importance, and seems to be not especially destructive in the United States. It infests all kinds of cereals, and as each larva may pass from one kernel into another, webbing them together until twenty or thirty grains are spoiled, it is apparent that considerable injury must result.

Figure 16. European grain moth. Three times enlarged.

This moth was first found in Connecticut, in 1906,* in a seed warehouse in Milford. It is now distributed throughout the northern states.

The adult is a slender moth with a wing-spread of half an inch, creamy white mottled with brown, and is shown in figure 16. Its work is shown in figure 1.

OTHER INSECTS OCCASIONALLY ATTACKING FOODS.

The large cabinet beetle, *Trogoderma tarsale* Melsh., frequently injuries seeds and is shown in figure 17. The small cabinet beetle, *Anthrenus verbasci* Linn., and the black carpet beetle, *Attagenus piceus* Oliv., occasionally attack and injure food products, though the latter is a more important pest of clothing.

* Report of this Station for 1906, page 305.

The larder or bacon beetle, *Dermestes lardarius* Linn., the red-legged ham beetle, *Necrobia rufipes* Fabr., and certain species of mites of the genus *Tyroglyphus* sometimes injure dried meats, cheese, dried fruits, cereals, etc. The cigarette beetle, *Lasioderma serricorne* Fabr., though primarily a pest of tobacco, feeds

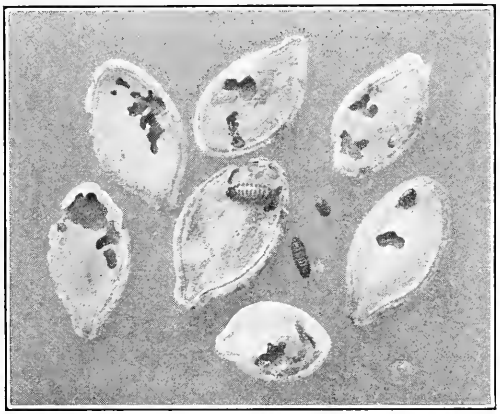

FIGURE 17. Seeds injured by the large cabinet beetle. Natural size.

upon the spices, rice, figs and many other food products. Then the cheese skipper, *Piophila casei* Linn., which occurs everywhere, often attacks cheese and the larvae may be found tunneling in it. Cheese should be kept covered and should be examined every day in warm weather. Hams and other kinds of meat are infested only in certain portions which can be cut off and the remainder used for food.

A species of book-lice, *Troctes divinatorius* Müll. (order Corrodentia), was found eating corn at the Station in 1900. The sample was stored in a ground glass-stoppered jar. The outer surface of the kernels was wholly eaten off, so as to render the variety wholly unrecognizable.

Cockroaches and ants are also frequently injurious in pantries and storehouses. The former are usually susceptible to the influence of powdered borax, and ants can usually be driven away by scattering naphthalene flakes about on the floor and shelves, especially where the ants have their runways.

The other insects mentioned in this chapter without control methods may be killed by heat or by fumigation.

CONTROL METHODS.

The chief methods for preventing damage by the insects mentioned in the foregoing pages are: the use of high and low temperature, air-slaked lime, pest proof packages and fumigation.

Temperature.

Temperature is recognized as an important factor in insect development, and often determines in a measure the number of annual generations of certain species. Extremes in temperature are sometimes employed for the control of insects.

HEAT.

It has long been known that heat will kill insects, and one of the simplest methods of destroying them in small packages of flour or other food products is to heat it in the oven for an hour or so. Following this idea Professor George A. Dean started some experiments in Kansas in 1910 to determine the fatal high temperatures for certain grain-infesting insects, and found that few insects can withstand a temperature of from 118°-125° F. for any length of time. In a mill there are accumulations of meal and flour on the floor, beams, machinery, and in the corners everywhere in which insects can breed. To keep a mill free from this accumulation and absolutely clean is almost an impossibility. By the use of heat, however, the insects can be killed from time to time without serious inconvenience, without shutting down the mill, and without great expense. It requires extra steam pipes sufficient to raise the temperature to about 120° F., and to keep it there for a period of five or six hours to allow the heat to penetrate the bins and bags of grain. Professor Dean has published three papers on this subject,* and any one interested should write to him for further advice.

Any grain or seeds which are intended for planting should not be heated to a point much greater than 130° F. as there is danger of injuring the vitality, which with some seeds ceases if the temperature approaches 150° F.

Any product to be used for food will not be injured by this

* Journal of Economic Entomology, Vol. IV, page 142, 1911; Vol. VI, page 40, 1913. Kansas Agricultural Experiment Station, Bull. 189, July, 1913.

heating method and even the eggs and larvae, as well as the adult insects, are killed by it.

COLD.

A low temperature is not so frequently used for destroying insects, yet it has been known for a long time that insect development is arrested or suspended altogether in cold storage.

Mr. J. A. Manter* of Storrs, Conn., states that the bean weevil will not breed in cold storage and suggests that beans be stored in unheated buildings. This idea may be carried out in practice with certain other stored food insects but the exact temperatures have not yet been determined for all species.

Air Slaked Lime.

A very simple and promising treatment to prevent weevil injury to peas, beans, cow peas and possibly to other kinds of

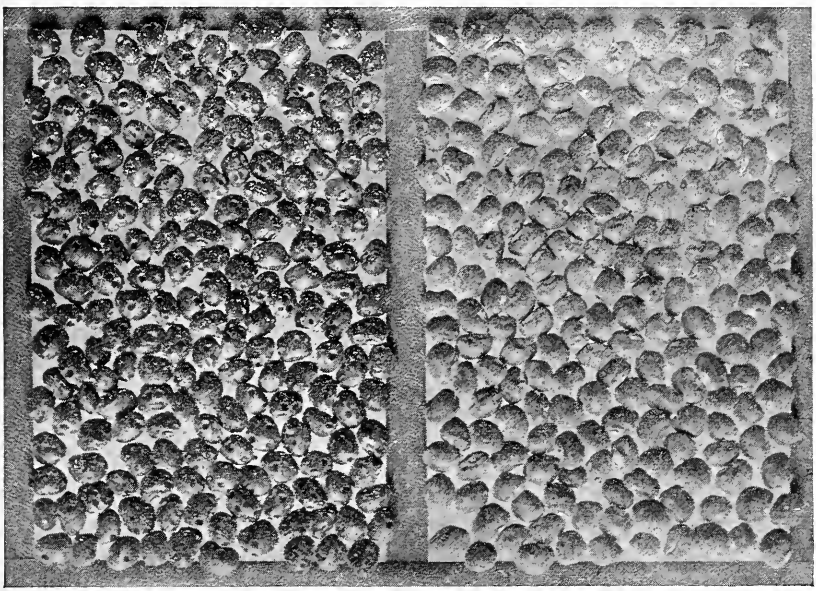

Figure 18. Effect of air slaked lime. Treated seeds at right. (After Metcalf, North Carolina Agricultural Experiment Station. Jour. Econ. Ent., Vol. 10, plate 3, fig. 2.)

* Journal of Economic Entomology, Vol. X, page 193, 1917.

seeds has recently been discovered by Mr. Z. P. Metcalf* of the North Carolina Station. This consists of applying air-slaked lime to the seeds, using one part by weight of lime to two parts of seeds when placing the crop in storage. For small quantities, say less than a half peck, Professor Metcalf advises the writer in a letter that four parts of lime should be used to one part of seeds; for quantities between a half peck and three bushels, use equal amounts of lime and seeds. The quantity of seeds to be stored thus influences the effectiveness of the treatment and necessitates greater proportions of lime for small quantities. In time this method may be found applicable to other kinds of seeds and against other insects. It has the advantage of being harmless to seeds and to the operator, as well as being convenient to procure and relatively inexpensive. Professor Metcalf is now completing further tests of this material. Figure 18 shows untreated seeds and those treated with lime.

Pest-proof Packages.

Materials sealed in glass or metal containers are usually safe against insects as long as they remain unopened. We have a number of records showing that the smaller beetles, like the saw-toothed grain beetle, will enter poorly stoppered glass bottles and jars and even tin-stoppered cans. The material is of course often infested before placing in the containers.

Mr. William B. Parker of the U. S. Bureau of Entomology has made investigations and suggests† a sealed paper carton for packing cereals which are to be placed upon the market. While this may prevent infestation in stores and warehouses, in the household many opened packages often attract insects, and if stored for a long time no paper package is insect-proof. Hence other methods must be resorted to, especially in dwelling houses, to keep the foodstuffs free from insect attack.

Fumigation.

Fumigation has long been practiced to kill insects in seeds and food substances. For this purpose two materials are commonly used, viz., carbon disulphide and hydrocyanic acid gas.

* Journal of Economic Entomology, Vol. X, page 74, 1917.

† Bulletin 15, U. S. Department of Agriculture, 1913.

CARBON DISULPHIDE (BISULPHIDE).

This is a colorless, ill-odored liquid which volatilizes at air temperatures, more readily in warm weather, and the fumes are deadly to all forms of insect life. Carbon disulphide may be purchased in pound bottles from any wholesale druggist, and as it is inflammable when the fumes are mixed with air, it should not be used by any one smoking, or at night with oil or gas lights near. As the fumes are heavier than air the liquid should be placed on top, rather than at the bottom of the grain, seeds or material to be treated. It should also be placed in a shallow dish to facilitate volatilization. The quantities used are about one pound to each 40 bushels of seeds, or to each 100 cubic feet of space. In a tight barrel containing grain or seeds, about one-half cupful of the liquid should be placed in a saucer on top of the seeds, the barrel covered tightly and allowed to remain all day or longer. For smaller receptacles, use proportionate quantities of the liquid. Carbon disulphide is more convenient, less dangerous to the operator, and its fumes penetrate better than hydrocyanic acid gas. A recent bulletin by Dr. Hinds* contains much information about carbon disulphide and may be obtained by applying to the U. S. Department of Agriculture, Washington, D. C.

HYDROCYANIC ACID GAS.

This is a deadly poisonous gas generated by putting together cyanide, sulphuric acid and water. Potassium cyanide was formerly recommended, but sodium cyanide is now the cyanide of commerce and is effective. The quantities for 100 cubic feet of space are as follows:—

Sodium cyanide	1 oz.
Commercial sulphuric acid	2 fluid ozs.
Water	4 " "

If a room is to be fumigated its cubic space must be ascertained and the chemicals carefully weighed or measured. It must be made reasonably tight, and provision must be made for opening from the outside at least one window or door, besides the exit. The generating jar may be earthen or stoneware but never

* Farmers' Bulletin 799, U. S. Department of Agriculture, June, 1917.

metal. The acid may be diluted with the water, the cyanide placed in a paper or cheesecloth bag, and when all is ready the operator should drop the bag into the jar and with bated breath retire at once and close and lock the door. One full inhalation of this gas will drop a man, and no carelessness should be permitted. The house or room should be exposed for at least two hours and may remain closed over night or over Sunday. The fumes do not penetrate as well as those of carbon disulphide.

Recently Mr. E. R. Sasscer of the U. S. Department of Agriculture has devised an apparatus for fumigating cotton bales, bags of seeds, etc. By removing the air and forcing the gas into a partial vacuum thus created, most insects are killed with a half hour exposure.* On account of the danger, trouble of generating, etc., the average farmer and householder will seldom use hydrocyanic acid gas and will find carbon disulphide or heat sufficient to meet his needs.

SUMMARY.

Much damage results each year in Connecticut to cereals and other stored food products from the attacks of insects. This injury has been estimated at five per cent of the total value of the products, or $200,000,000.00 each year for the United States, and is wholly preventable.

The insects are chiefly beetles (Coleoptera) and moths (Lepidoptera). The former include the meal worms, cadelle, pea and bean weevils, drug store beetle, confused flour beetle, rust-red flour beetle, saw-toothed grain beetle, granary weevil, rice weevil, large and small cabinet beetles, black carpet beetle, larder beetle, red-legged ham beetle, and cigarette beetle. The latter include the Indian meal moth, Mediterranean flour moth, meal snout moth, Angoumois grain moth, and European grain moth. Other insects like the cheese skipper (a fly), a book louse, ants, cockroaches, and even mites occasionally cause damage.

The most important of these pests are described briefly in the preceding pages.

* Bulletin 186, U. S. Department of Agriculture, 1915.

Most of these insects may be destroyed by raising the temperature to a point between 120° and 130° F. for five or six hours. The vitality of seeds is endangered if the heat approaches 150° F. but the material would not be injured for food.

Food kept in cold storage will not be injured by insects.

Various pest proof packages have been devised, but food often becomes infested in them, and no package is pest proof after the seal has been broken.

Air-slaked lime applied to seeds when placed in storage will prevent most of the damage caused by the pea and bean weevils. The proportions are as follows: For small quantities, say less than a half peck, four parts of lime to one part of seeds; between a half peck and three bushels, equal parts of lime and seeds; for greater quantities, one part of lime to two parts of seed.

Fumigating with carbon disulphide, using a half cupful to a barrel, will rid the material of insect life. This liquid should be placed on top of the infested material, and should not be used near a fire as it is inflammable. The container should be tightly covered for twenty-four hours or longer.

Hydrocyanic acid gas may also be used but is not advised except in particular cases, as it is deadly to breathe and does not penetrate masses of flour and grain readily. Seeds and food materials if thoroughly aired are not injured by carbon disulphide or hydrocyanic acid gas, either for food or for planting.

For more detailed information on this subject the reader should refer to the pages of this bulletin.